

UNDERGROUND DISPOSAL OF WASTES IN BRITAIN

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ABSTRACT

The requirement of the Control of Pollution Act 1974 to license all waste disposal facilities, has identified 25 sites in England and Wales where wastes are discharged under gravity to disused mineral workings. The problems and advantages of waste disposal into coal mines and salt cavities are discussed, and the future potential for underground disposal of liquid or solid waste in Britain is reviewed on the basis of geological suitability.

INTRODUCTION

Disposal of wastes to underground cavities has been practised in Britain for over a century but only recently since the implementation of the Control of Pollution Act 1974, have full details become publicly available. Part I, Section 5, of this Act requires that all waste disposal facilities such as landfills or incinerators, be licensed by Waste Disposal Authorities set up following local government reorganisation in 1974. In the case of applications to dispose of controlled waste through shafts, galleries, wells, boreholes, or pipes, into fractures, fissures or intergranular pore spaces in geological formations it is recommended that Waste Disposal Authorities consult the Institute of Geological Sciences before granting a licence. In this way the possibility of adverse effects that have occurred in the past especially in North America (ref. 1) can be professionally assessed. Apart from the pollution of ground or surface water, these include microseismic effects resulting from lubrication of fault zones under stress, ground subsidence due to solution or weakening of the host rock by the injected fluid, well clogging due to the formation of biological slimes or precipitates, and explosions if wastes are chemically incompatible. In addition wastes may sterilise mineral reserves and low grade geothermal resources and make the host rocks in the area unsuitable for other uses.

PRESENT SITUATION

All 25 applications received involve the gravity discharge of solid or liquid wastes into disused mineral workings and no proposal has been made to inject liquid wastes under pressure into deep permeable formations (Fig. 1).

The discharge fall into three major categories, viz:-

- 1) Disposal of liquids and sludges to disused coal workings.
- 2) Discharge of liquids and sludges into salt cavities.
- 3) Filling old shafts and mined voids with solid inert wastes.

Disposal to disused collieries

Waste disposal into disused coal mines constitutes 19 of the applications received which apart from one, were all operating prior to licensing; one at least had been in use since 1890.

The method of mining commonly carried out during the nineteenth century was "pillar and stall" in which 60% or more of the seam was removed and pillars of coal left at regular spacings to support the roof. Often horizontal adits driven into the hillside at a lower level were used to gravity drain the workings, but only after the Coal Mines Act of 1872, was it compulsory to record the extent of working and details of drainage, so that the positions or even the existence of some older shafts which could form pathways for wastes to return to the surface, are unknown.

Recorded instances of pollution (refs. 2 and 3) include a case whereby industrial effluent discharged through a borehole reappeared in an adjacent factory where groundwater was abstracted from the same formation for cooling purposes, and was then discharged into a canal.

A landfill investigated by the Institute of Geological Sciences in a sandstone quarry in Central Scotland (refs. 4 and 5) was reported to be underlain by two old shafts used to work at least six coal seams and ironstone to a depth of 168m below ground level. Because of the ease with which liquids drained into the ground, the site became a major regional disposal facility in the early 1970's for toxic wastes including strong acids, alkalies, phenolic tars, oils, metallic sludges and PCB's. Not surprisingly, the wastes entered the workings where oils formed a separate phase above the mine water. Investigation boreholes drilled around the site penetrated oil-filled workings more than 300m from the landfill, and showed that leachates had moved a similar distance through fissured sandstone with negligible attenuation. The full area of contamination is difficult to determine because neither the boundaries of the pillar and stall workings, nor the occurrence of void spaces within them is known exactly. The available plans of the extraction area indicate considerable potential for waste movement, but fortunately, no wastes have been detected in surface streams, although adits and shafts at a lower elevation than the site could theoretically provide pathways back to the surface.

Not all mineshaft disposal need be associated with similar risks. A relatively modern colliery at Walsall Wood in Staffordshire was worked without the need for extensive drainage, and abandoned in 1964. The mine was developed between 380-500m below ground level in a down faulted block of Lower Coal Measures hydraulically isolated from the surface by a capping of at least 300m of relatively impermeable Etruria Marl, and surrounded by relatively impermeable Upper Coal Measures and Lower Palaeozoic shales.

In 1966 a waste disposal company started discharging a variety of wastes including inorganic acids, heavy metals, phenols and oils, through a shaft, with the condition that the liquid level in the shaft should not rise higher than 150m below sea level. The average rate of disposal was $135 \times 10^3 \text{ m}^3/\text{a}$, but after 10 years the brick lined shaft collapsed. A nearby borehole drilled to monitor water levels in connected workings was then licensed so that the company could discharge for a limited period landfill leachate that had accumulated in an adjacent containment site in their ownership.

Subsequently, the company built a waste treatment plant from which they have won the right, following a Public Inquiry, to discharge certain effluents into the mine workings subject to conditions. These include, capping surrounding shafts, drilling monitoring boreholes and providing vents to control the release of noxious or explosive gases.

Except for this site, the general policy of waste disposal authorities has been to grant time limited licences for discharges established prior to the Control of Pollution Act, with the condition that a consultant's report be produced to assess the possible environmental impact of continued use (ref. 6). This gives the waste producer time to seek alternative means of disposal or to install waste treatment facilities, if required.

Disposal to salt cavities

Cavities formed by solution mining in the Triassic salt fields of Lancashire and Cheshire (ref. 7), are also used for the disposal of liquids and sludges. A single licence has been issued covering 53 cavities in a Cheshire brine field for in-house disposal of wastes from the associated chemical manufacturing processes. Wastes include muds and brines contaminated with mercuric sulphide, calcium sulphate and carbonate, magnesium hydroxide and a variety of chlorinated hydrocarbons including carbon tetrachloride, hexachlorebenzene and derivatives and underground disposal has substantially replaced the former practice of lagooning waste at the surface. Solution extraction of salt is stopped before the maximum cavity size is reached to allow for subsequent solution by wastes not saturated with respect to brine. Chemical compatibility of chlorinated residues is achieved by not discharging to the cavity more liquid than that which on complete decomposition to hydrochloric acid, could not be neutralised by the alkali in the cavity.

Because of the geological and engineering controls inherent in developing brine fields this method of disposal has considerable merit. However, unless the waste can be made chemically inert, or immobilised e.g. by solidification, these operations must be regarded as storage. On the other hand future recovery of wastes for recycling may be possible should it ever be economically viable to do so.

Disposal of solid inert wastes to mine shafts and cavities

In 6 cases, licences have been issued for the disposal of relatively inert solids into disused shafts and galleries. The operations are usually of short duration and are undertaken for reasons of safety or to prevent surface subsidence.

FUTURE FOR UNDERGROUND WASTE DISPOSAL

Apart from rare cases typified by Walsall Wood, the older pillar and stall coal mines are not regarded as suitable for liquid waste disposal because of flooding, and the poor or incomplete abandonment plans, and other uses such as for water storage and river regulation may be more appropriate (ref. 8). Salt cavities will continue to be used for long term storage of liquids and sludges, but could also be used for temporary storage of low level radioactive effluents which could be disposed of elsewhere once their radiotoxicity had decayed to acceptable levels.

Despite the absence of pressure injection wells in England and Wales, there are a number of potentially suitable geological formations which could be used especially if hydraulic fracturing were to be employed. These include the producing oil field in the Midlands and South of England, large scale basinal or small scale anticlinal structures containing permeable formations at depth e.g. Lower Carboniferous or Devonian, as well as major confined aquifers containing saline or poor quality water. The Palaeozoic basement which occurs at relatively shallow depth over much of Southern England may have potential, but in all cases rigorous investigation is required and any decision to proceed should only be made after alternative disposal options have been fully evaluated and the competitive use of formations in the region considered for such things as mineral exploitation or geothermal energy. The present relative lack of information on the deep geology of Britain militates against underground disposal and, in the near future, only areas with well proved geological structures such as exhausted oil fields and brine fields, are likely even to be considered as candidates.

However, existing dry cavities or those from which water could be excluded (ref. 9) could offer potential for dry packaged wastes. These include disused railway tunnels or disused gypsum, limestone, ironstone, anhydrite, salt or potash mines, and in some areas, non ferrous metal mines. In future it may be feasible to mine rather than quarry rock aggregate at the surface, offsetting the extra cost against the value of the void created either for storage of wastes or for other uses (ref. 10 and 11).

A decision as to whether any formation can be used for either irretrievable disposal or retrievable storage must be based on the confidence with which the behaviour of the geological system can be predicted. Creating voids in a formation chosen for its stability, hydrogeological and geochemical characteristics, and engineering it if necessary to provide additional barriers to waste migration would minimise these uncertainties. Although such measures may prove expensive, the need to safely isolate wastes in an environmentally acceptable way may well favour this form of underground disposal of wastes in the future.

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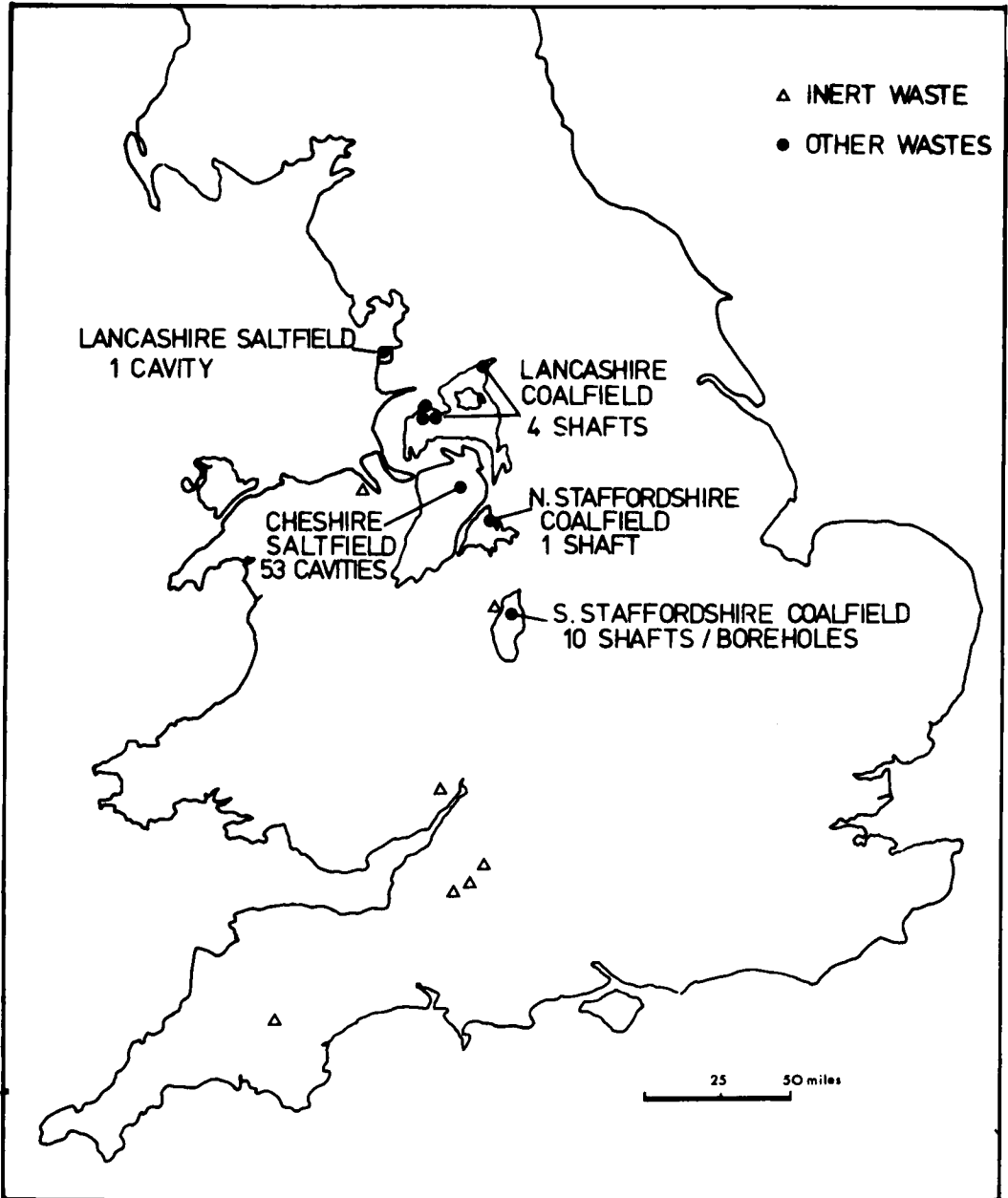


FIG 1 LOCATION OF UNDERGROUND WASTE DISPOSAL FACILITIES IN ENGLAND AND WALES